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Introduction to Life Cycle Assessment
Scoping & Inventory

US EPA Region X
October 8, 2009
Rita Schenck
American Center for LCA, IERE www.iere.org

Institute for Environmental Research and Education

Rita Schenck

- Environmental non-profit (501c3)
- ***Supports Fact-based Environmental Decision-Making***
- Headquartered in Washington State
- Diverse funding base (private, public, business, fee-for-service)
- ***Strongly believes that Business must drive environmental improvement***

American Center for Life Cycle Assessment

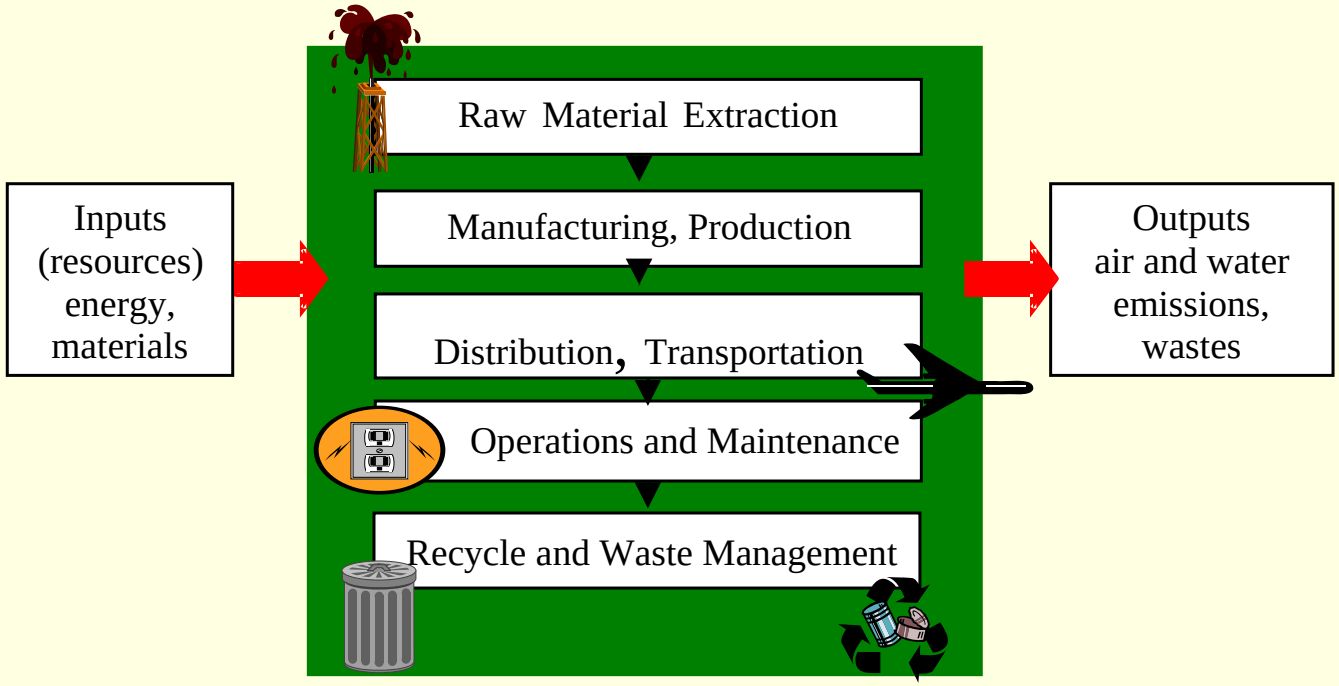
www.lcacenter.org

- Professional society for LCA in the USA
- Annual Conference, growing over 30% per year
- Next year in Portland November 2 – 5
- Certification for LCA Professionals

Topics for Today

- What is life cycle assessment
- Scoping a life cycle assessment
  - Goal
  - Audience
  - System Boundaries
  - Functional Units
- Concepts in life cycle inventories
  - Unit processes
  - Ecosphere and technosphere flows
  - Allocation
  - Economic input-output LCA
  - Data quality & statistics
- Resources

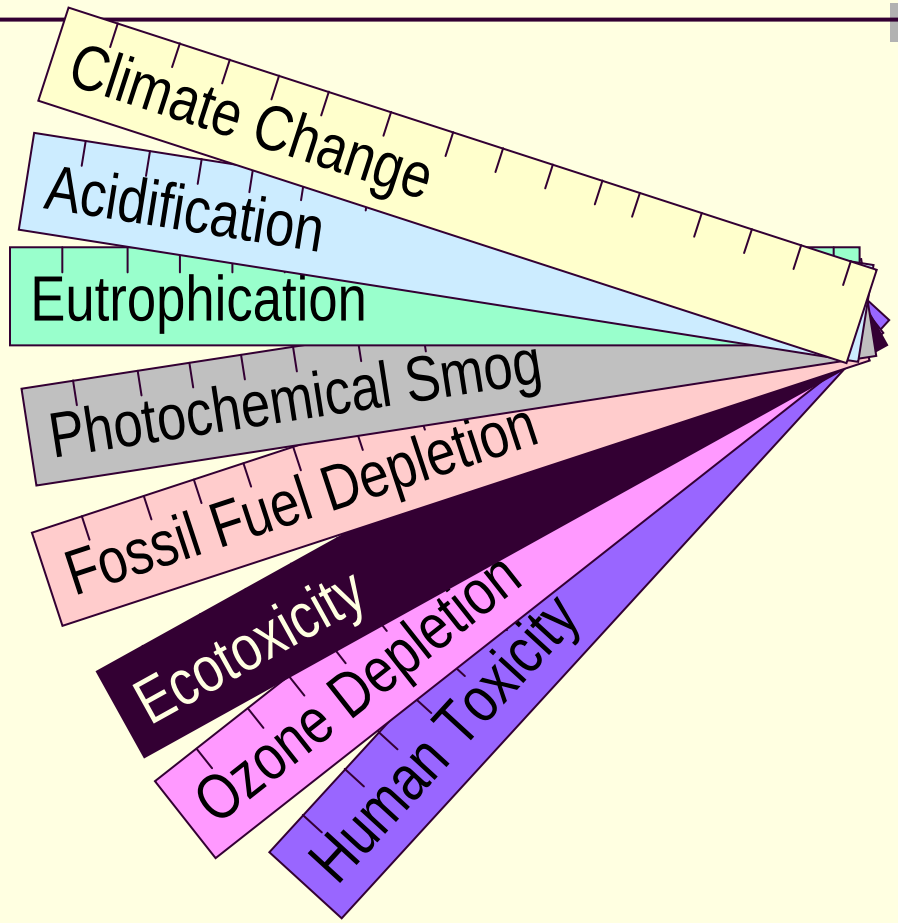
Systems Analysis; Input-output Life Cycle Inventory



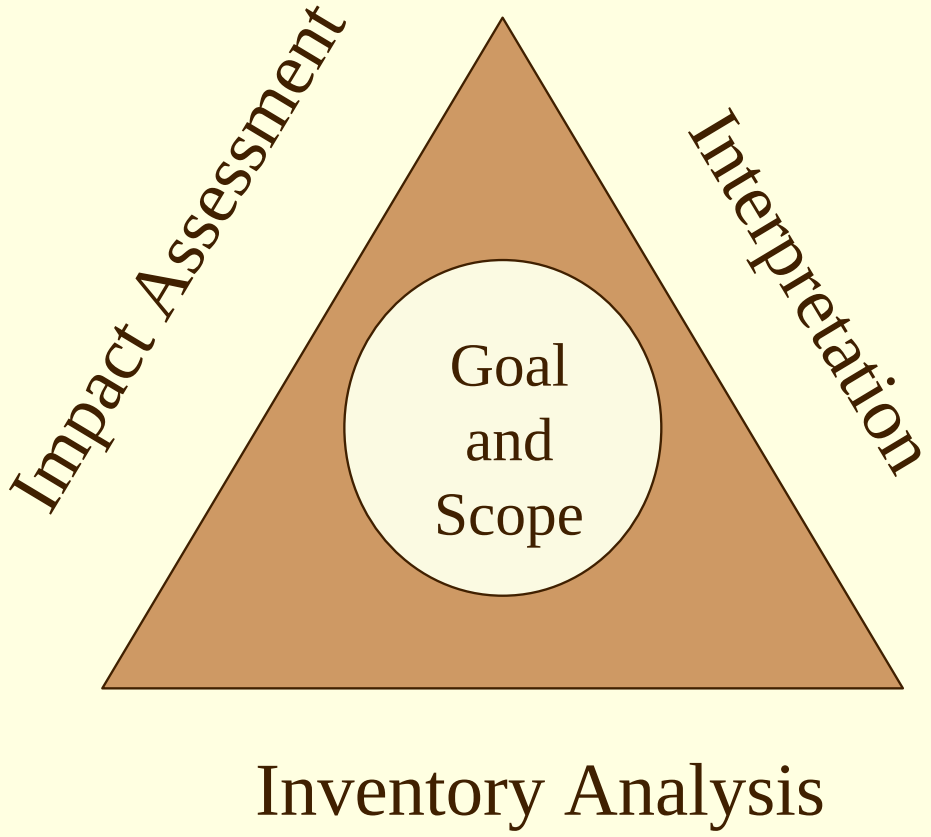
Industrial System

The science of measuring the environmental performance of products & services

Indicators of All Impact Categories



Phases of a Life Cycle Assessment

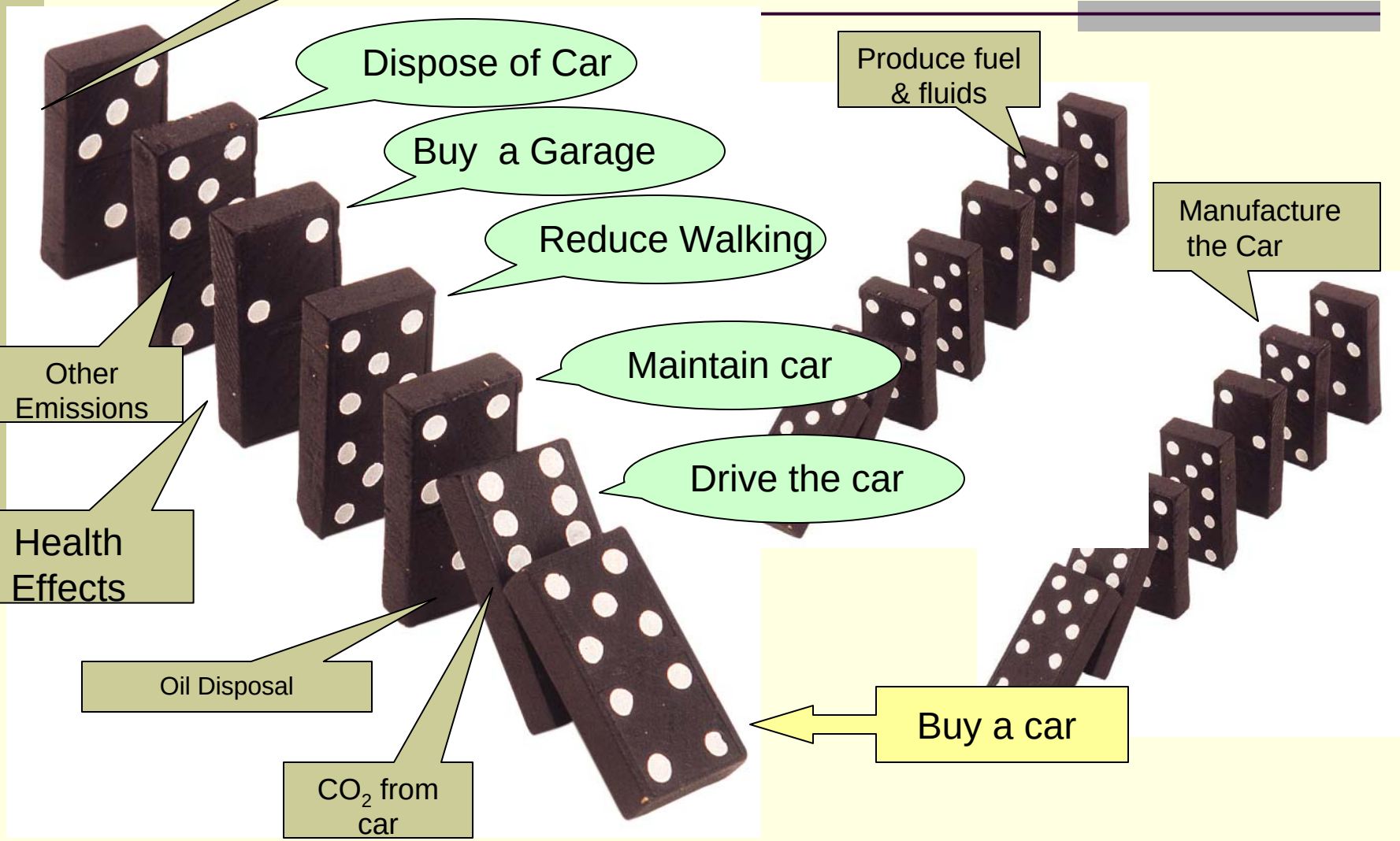


ISO and the 14040 series

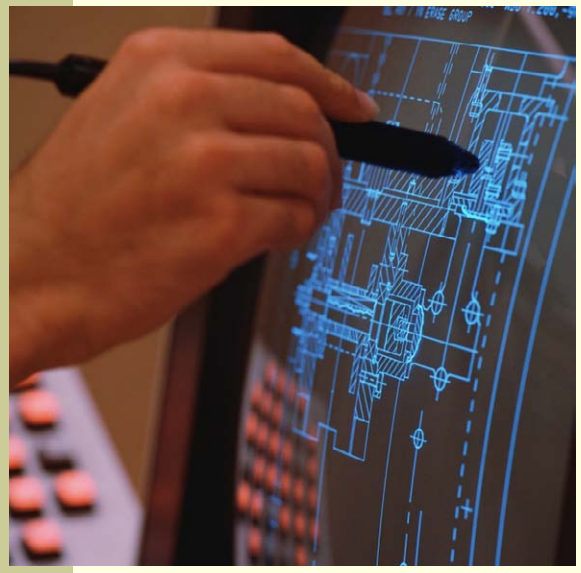
- ISO makes voluntary standards to support international trade: ISO is sister organization of WTO
- 14040 series are guidance on how to do LCA's
- Regulation & legislation based on LCA is presumed not to present technical barriers to trade under the WTO

Scoping LCA

Life Cycle Thinking



Who is your audience?



Internal Designers

Business to Business

Public

What is your goal?

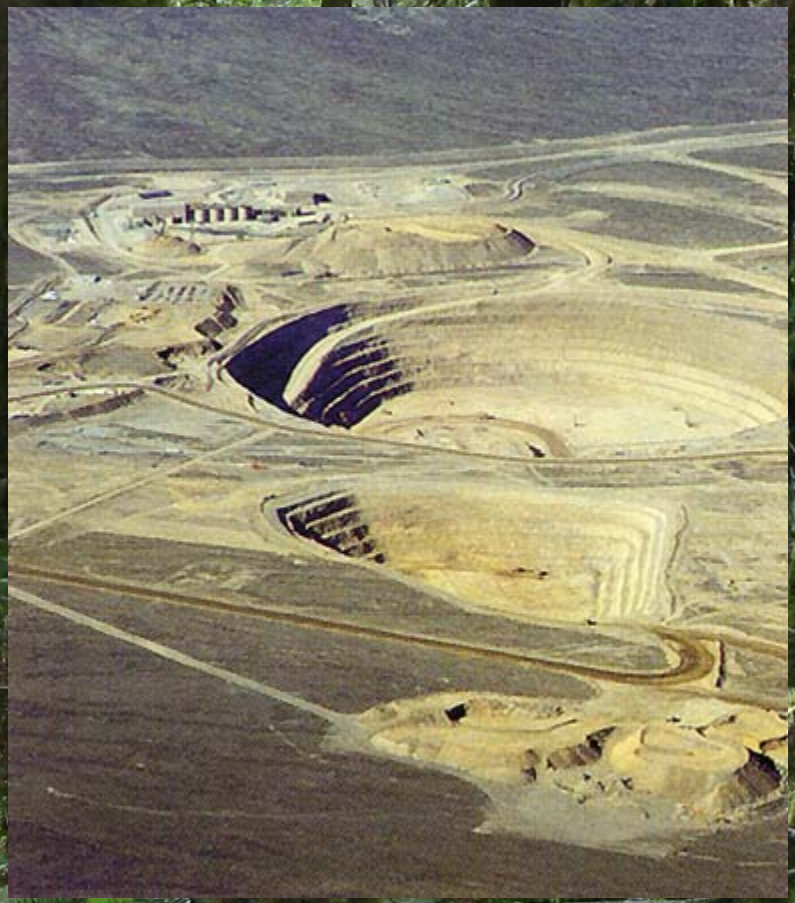
- To understand the environmental impacts of your product?
- To understand where those impacts come from (so you can get better)?
- To provide information to your customers?
- To market the environmental virtues of your product?
- To compare one product to another (or others)
- To claim that one product is environmentally superior to another? (this is called a comparative assertion)

GI-GO

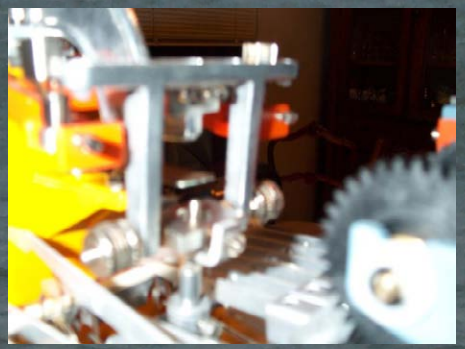
Required levels of review

- Internal use: no external review required
  - An internal expert review may be desired
- External use: critical review
  - An external, unaffiliated expert
  - A team of at least three reviewers, interested parties

Raw Materials Extraction



Manufacturing



Transport

Use & Maintenance

Where the system function happens

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Institute for Environmental Research & Education

Landfill, Minnesota

Disposal

West Point Treatment Plant, Seattle

Typical LCA Physical System Boundaries

- Cradle to Grave
- Cradle to Gate (e.g. commodities)
- Gate to Grave (market studies)
- Gate to Gate (specialized unit process studies)
- Well to Wheel (for automotive fuels)

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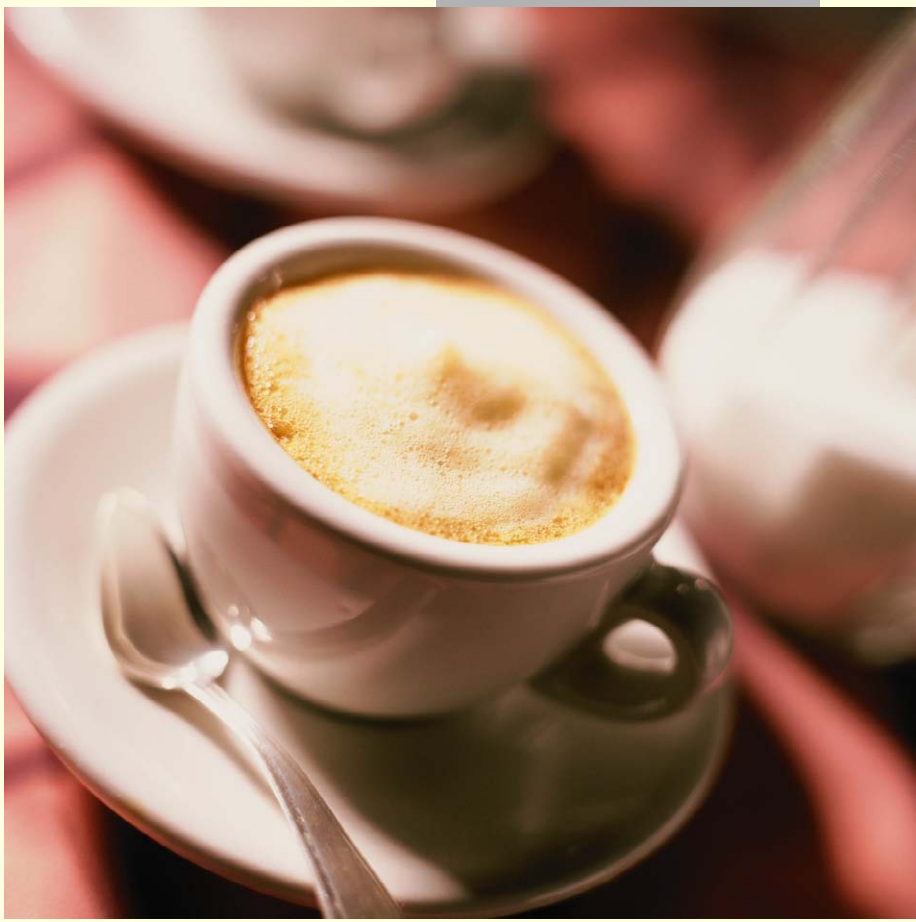
Questions?

System Function & Functional Unit

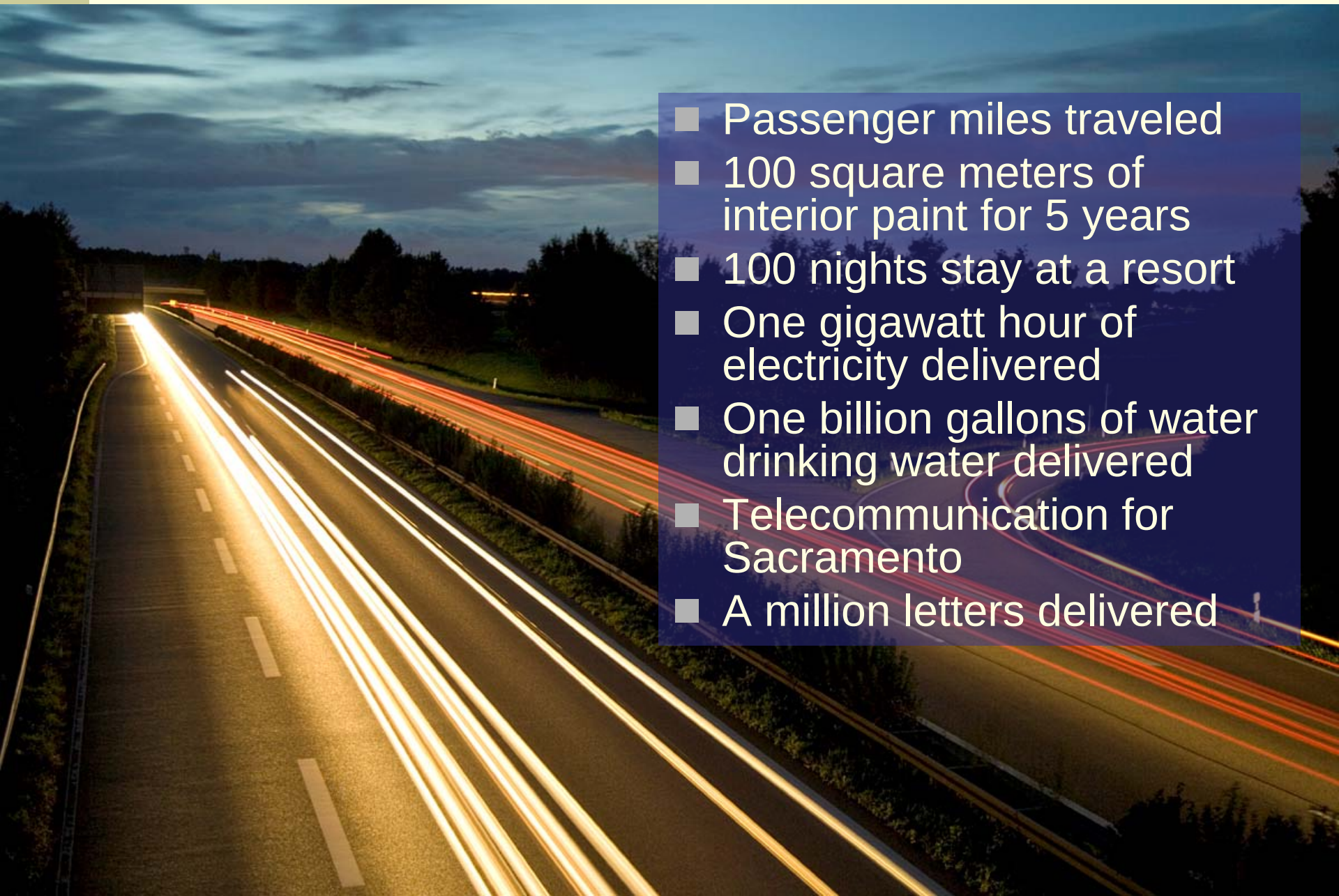
- Only unique part of LCA
- Connects social benefits (goods and services) to environmental impacts
- Makes the Market drive environmental improvement

System Function & Functional Unit

- Service Provided = Function
- Example: drinking container
- Functional unit:
  - Time, extent, quality
- Example:
  - Containers for year's worth of use of 12 ounce hot beverage at a college
- Permits comparison of single vs. multiple use containers



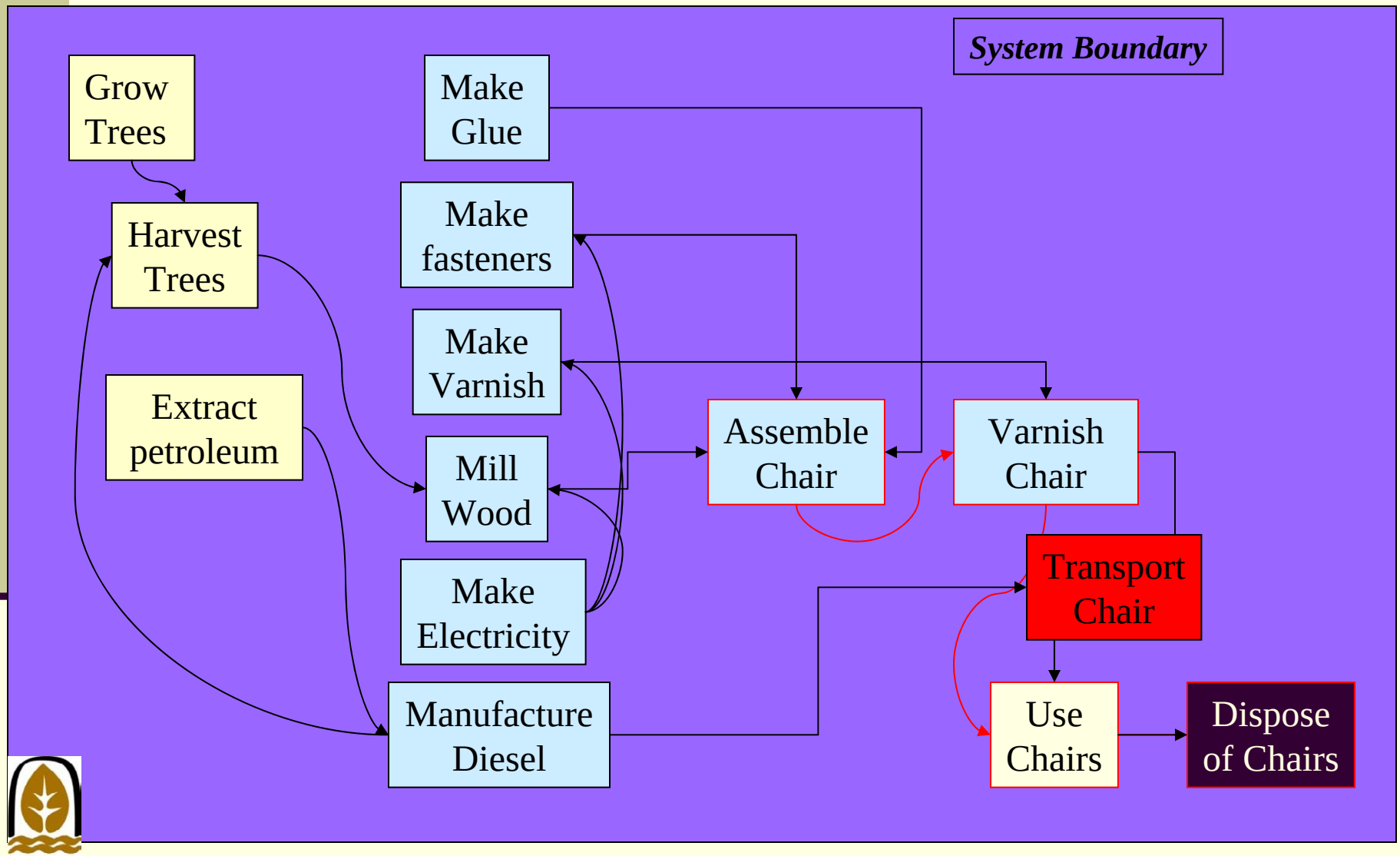
Functional Units Additional Examples



- Passenger miles traveled
- 100 square meters of interior paint for 5 years
- 100 nights stay at a resort
- One gigawatt hour of electricity delivered
- One billion gallons of water drinking water delivered
- Telecommunication for Sacramento
- A million letters delivered

System for Wooden Chairs

System function: child school chair
useful for 20 years: unit = 1 chair



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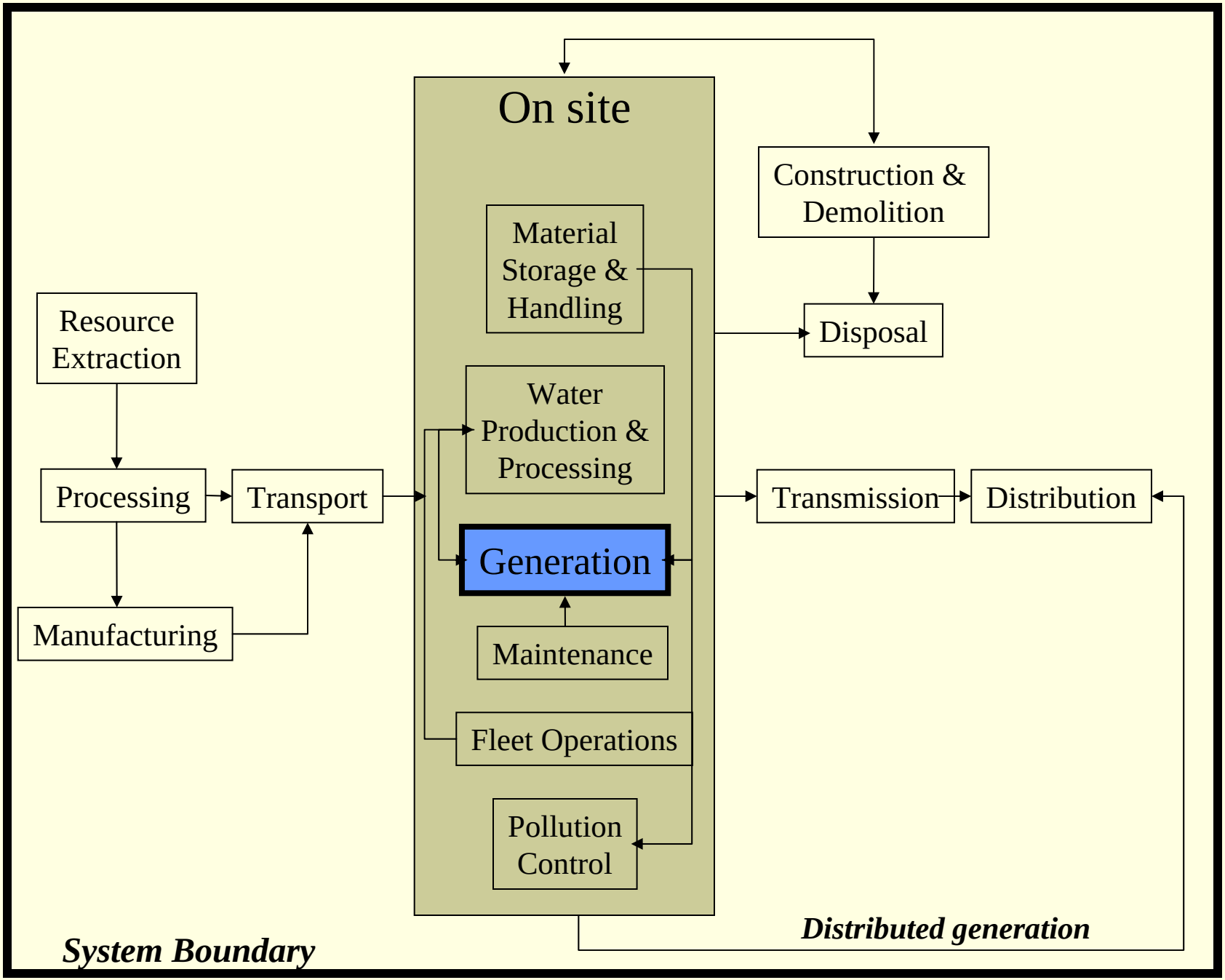
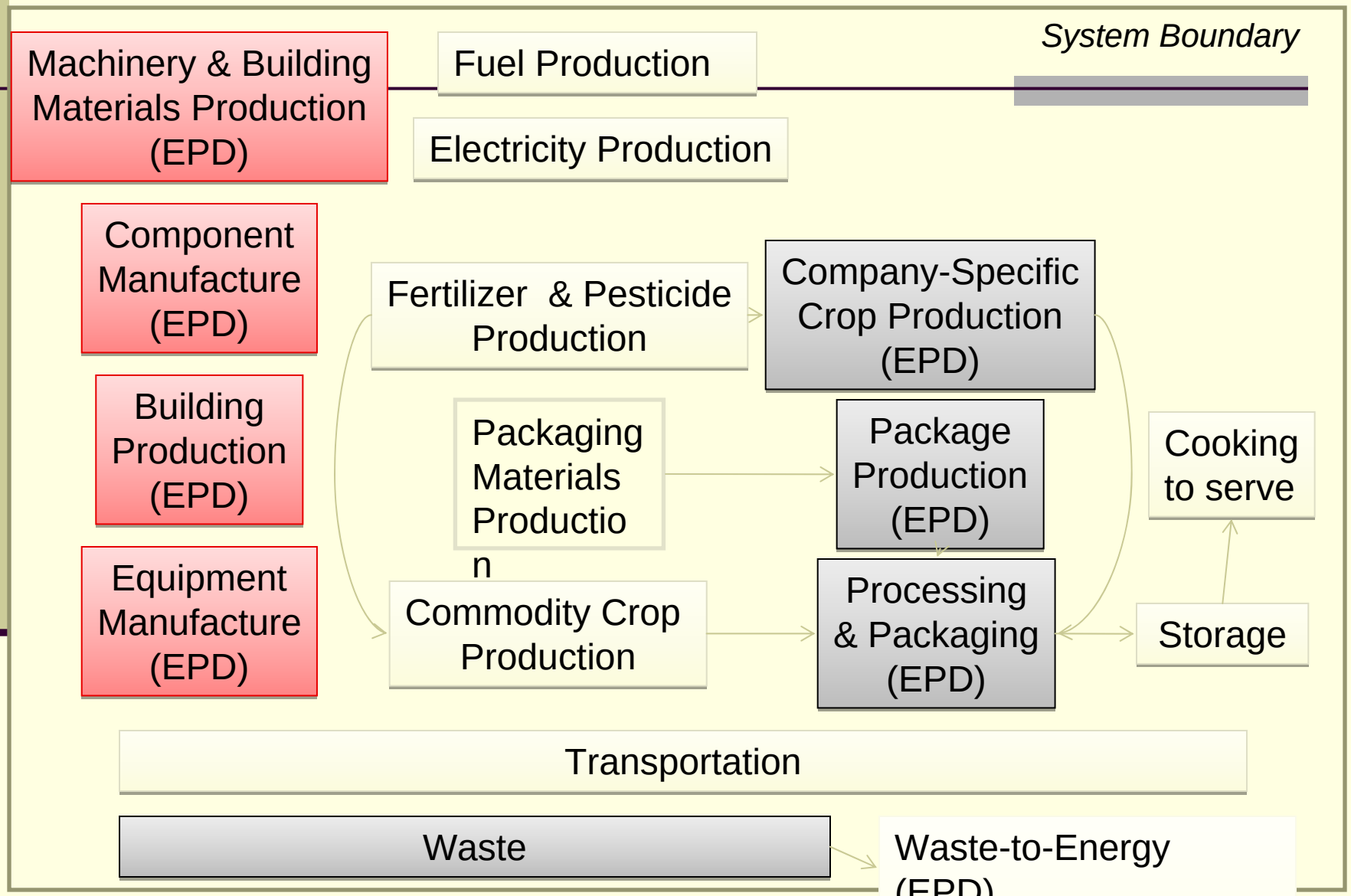

On site
Construction & Demolition
Material Storage & Handling
Resource Extraction
Disposal
Water Production & Processing
Processing
Transport
Transmission
Distribution
Generation
Manufacturing
Maintenance
Fleet Operations
Pollution Control
Distributed generation
System Boundary

Usually Excluded

Background (average)

Foreground Data

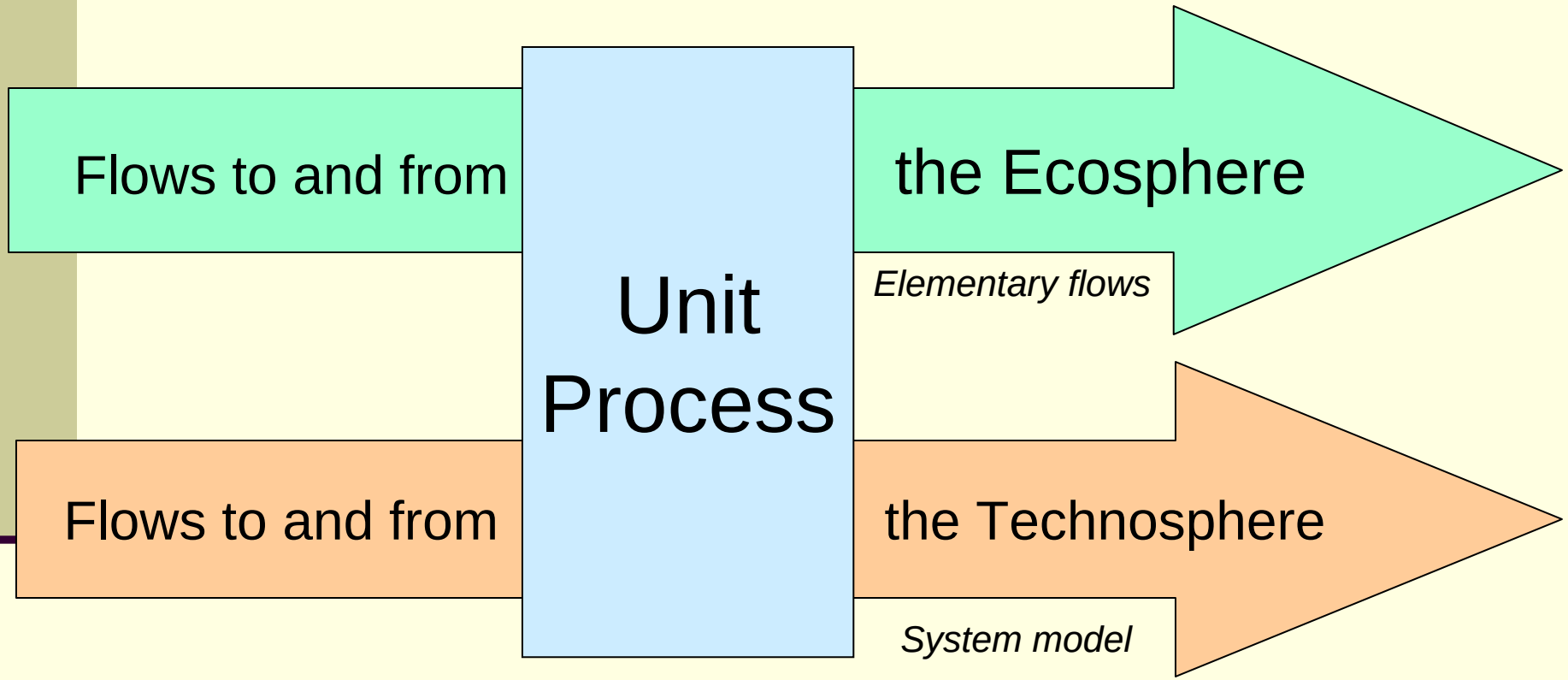
Earth sure Agriculture EPD System



Note: Connections to energy, transportation & waste not shown

Unit Processes: the fundamental unit of the LCA

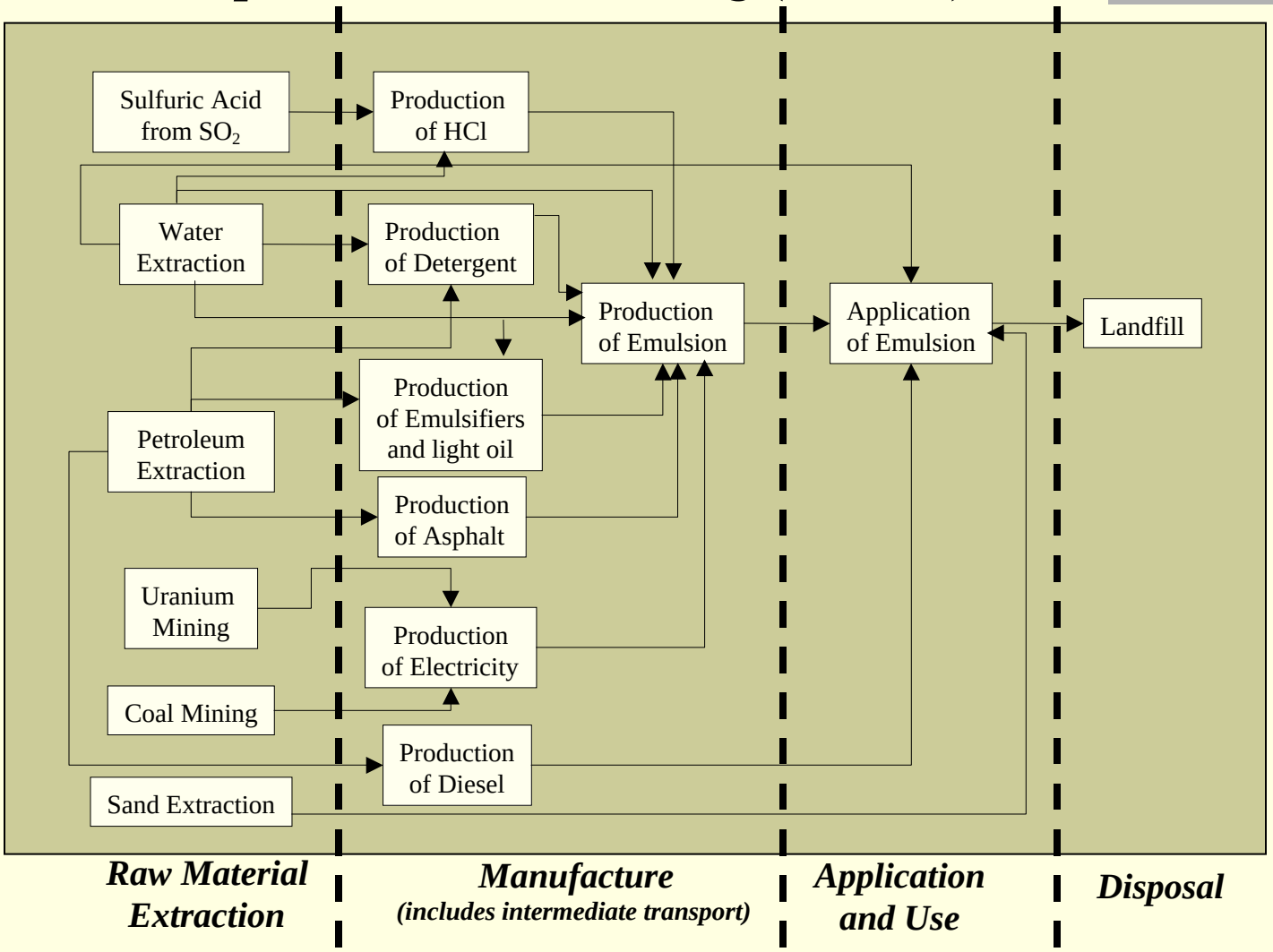
Inventory of a unit process



Asphalt Emulsion

System Function:
20 year lane mile in average condition

Asphalt Emulsion Coating (GSB 88)



Inventory elementary flows

Not a comprehensive list, but a minimum list

Resources

- Electricity (location)
- Water (location & type)
- Fuel (in ground)
- Minerals (in ground)
- Biomass (harvested)
- Land use (area & location)

Wastes

- Solid waste
- Radioactive Waste (high, low, medium)
- Hazardous Waste

Air

- CO_2
- CO
- PM (10, 2.5)
- CH_4
- SO_X
- NO_X
- NH_3
- Hg
- Pb
- VOC (NM)
- Dioxin
- PAH's

Water

- COD
- TDS
- TSS
- BOD (5,7,10)
- Flow
- ΔTemperature
- NH3 (as N)
- TKN (as N)
- NO3, NO2 (as N)
- PAH's
- Phosphates (as P)
- Cu
- Ni
- As
- Cd
- Cr
- Pb
- Hg

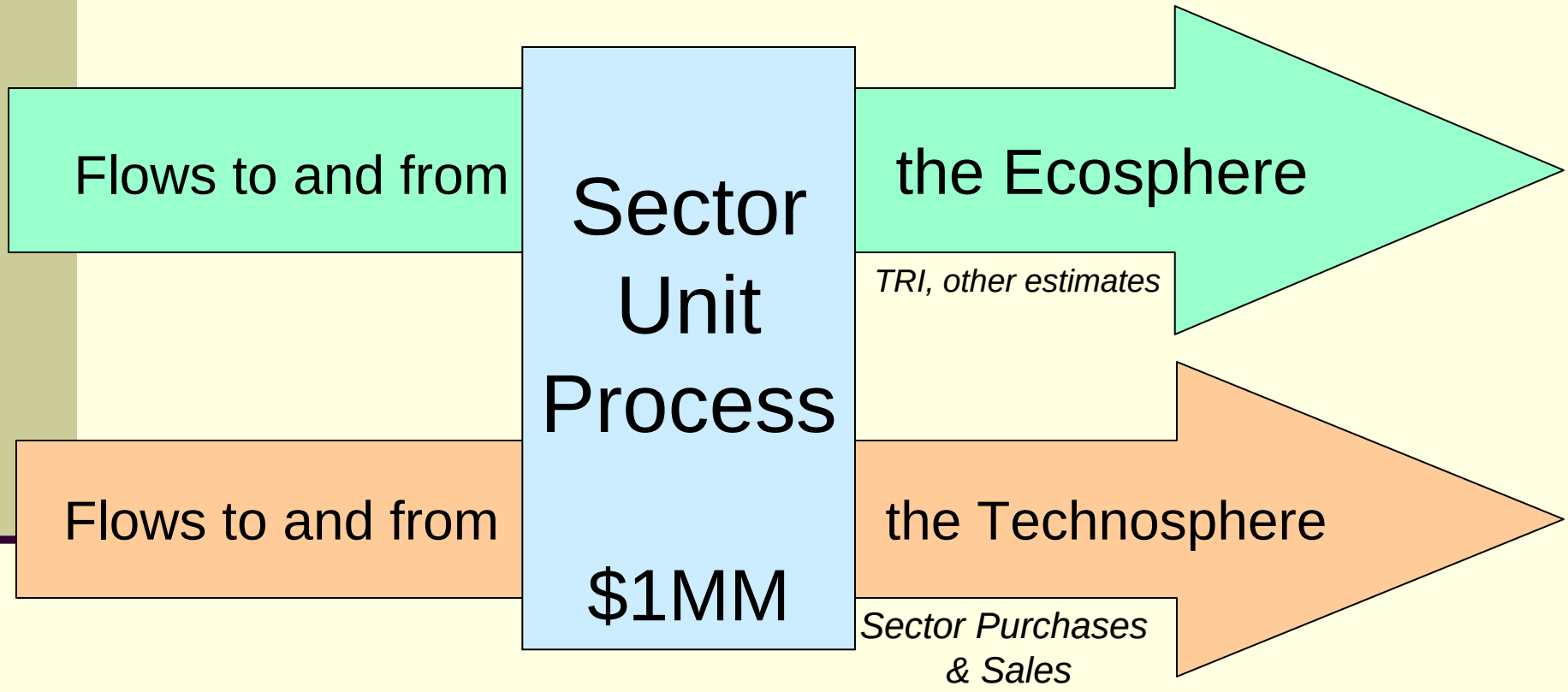
Typically data represents an annual average

Questions?

Economic input-out life cycle analysis

- Method developed at Carnegie-Mellon University
- Combines economic input-output tables with economy-wide estimates of sectoral pollution to estimate the environmental impact of a dollar spent in a given industry
- http://www.eiolca.net/Method/eio-lca-method.html

Inventory of an economic sector



Allocation

- What do you do when more than one product is made from a unit process?
  - Subdivide to smaller unit processes
  - Do system boundary expansion
  - Allocate via physical parameter
  - Allocate via economic value

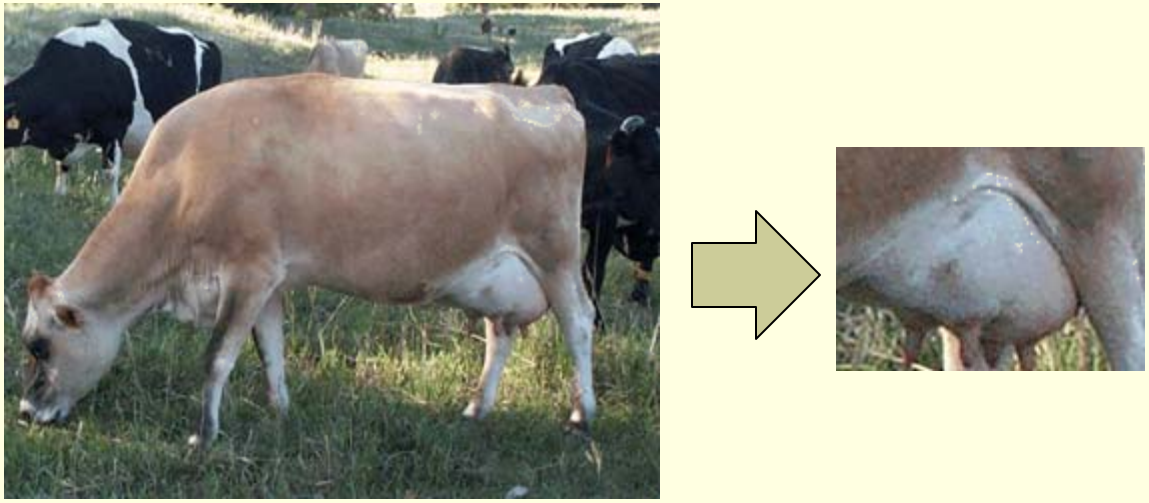
Consider dairy cows They make

- Bull calves(sold for veal)
- Heifer calves (sold for veal & breeding stock)
- Milk
- Hamburger at end of life
- Leather
- Bone meal?
- Manure

How can we allocate the impacts of growing cows to the different goods?

One option: Sub-unit processes

- Pursued by the University of Arkansas in their study of milk production
- Identified biochemical pathway and energy burden to create milk, separate from growth & maintenance



Another Option: System Boundary Expansion

-

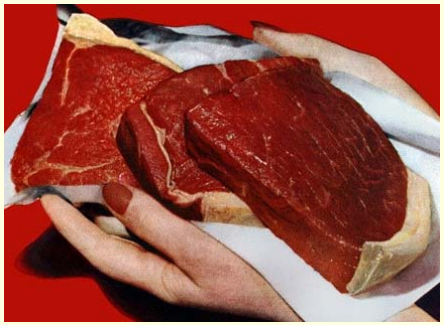
=

Another way of looking at it is that you are including meat and milk production in the system function, for a mixed functional unit

System boundary expansion only works when there is another system providing the same function

Another Option: Economic Allocation

$ = $ + $



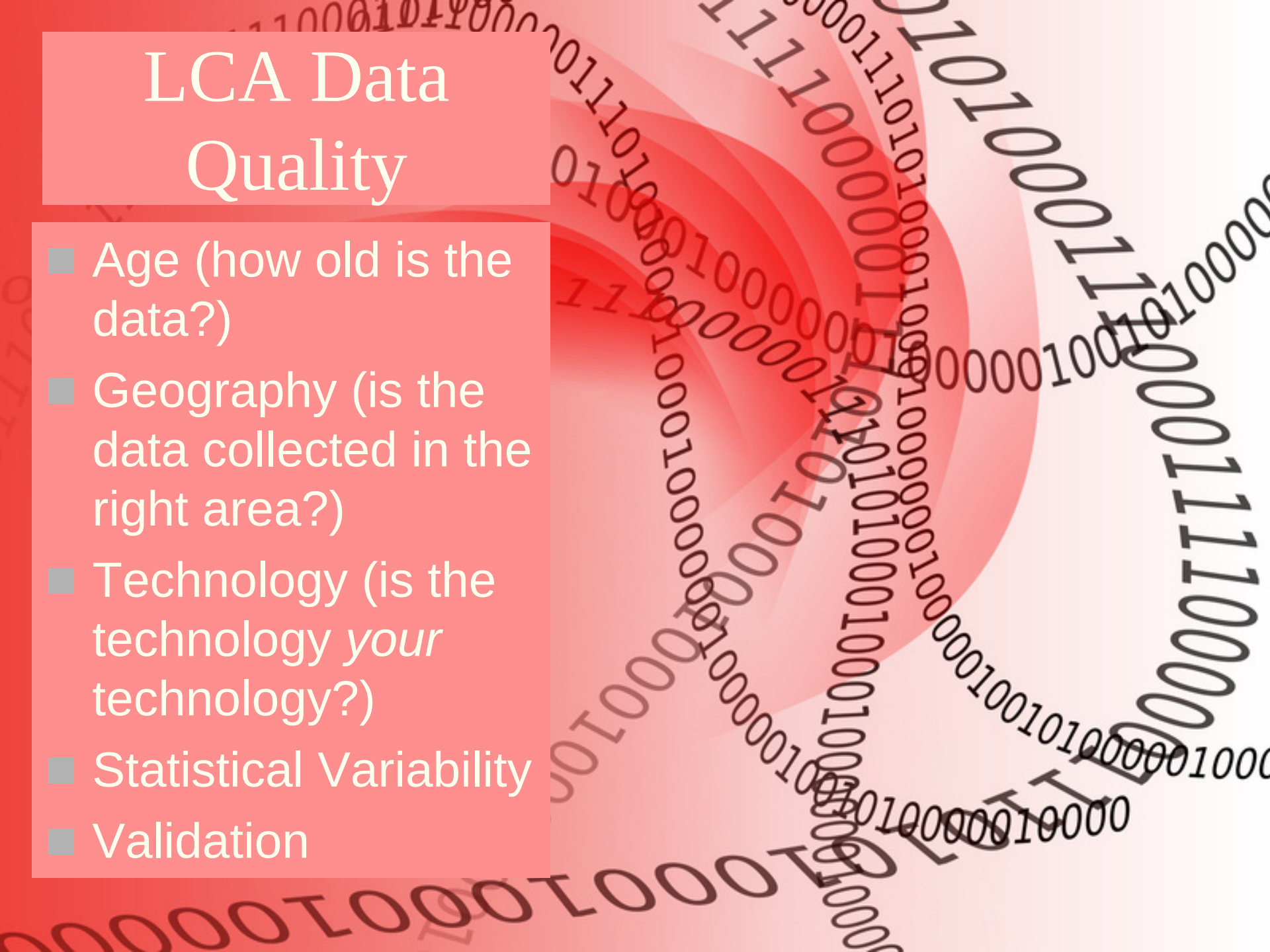
We divide the total impacts by the economic value of the products

Consider a Refinery

Studies show that allocating by mass of products or by energy or by cost provides essentially the same results

LCA Data Quality

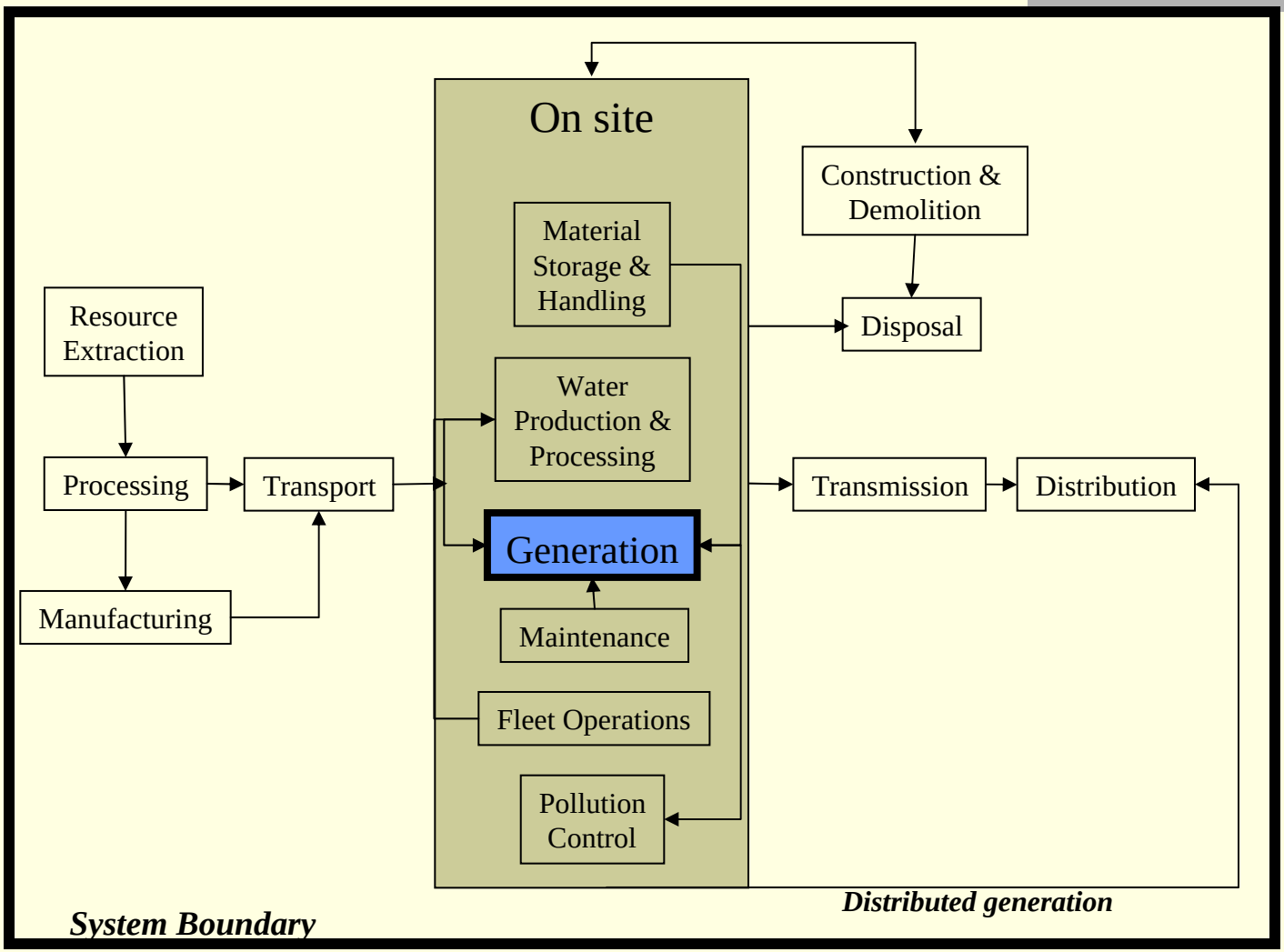
- Age (how old is the data?)
- Geography (is the data collected in the right area?)
- Technology (is the technology *your* technology?)
- Statistical Variability
- Validation



Where does data come from?

- **Primary data**: you measure it yourself
  - Purchase and sales data (technosphere)
  - Stack tests & water monitoring (ecosphere)
- **Secondary data**: someone else collected the data
  - Scientific studies
  - Government reports
  - Technical reports from vendors
- **Tertiary data:** an aggregation of secondary data
  - Commercial databases
  - Government databases

Data Aggregation: Vertical

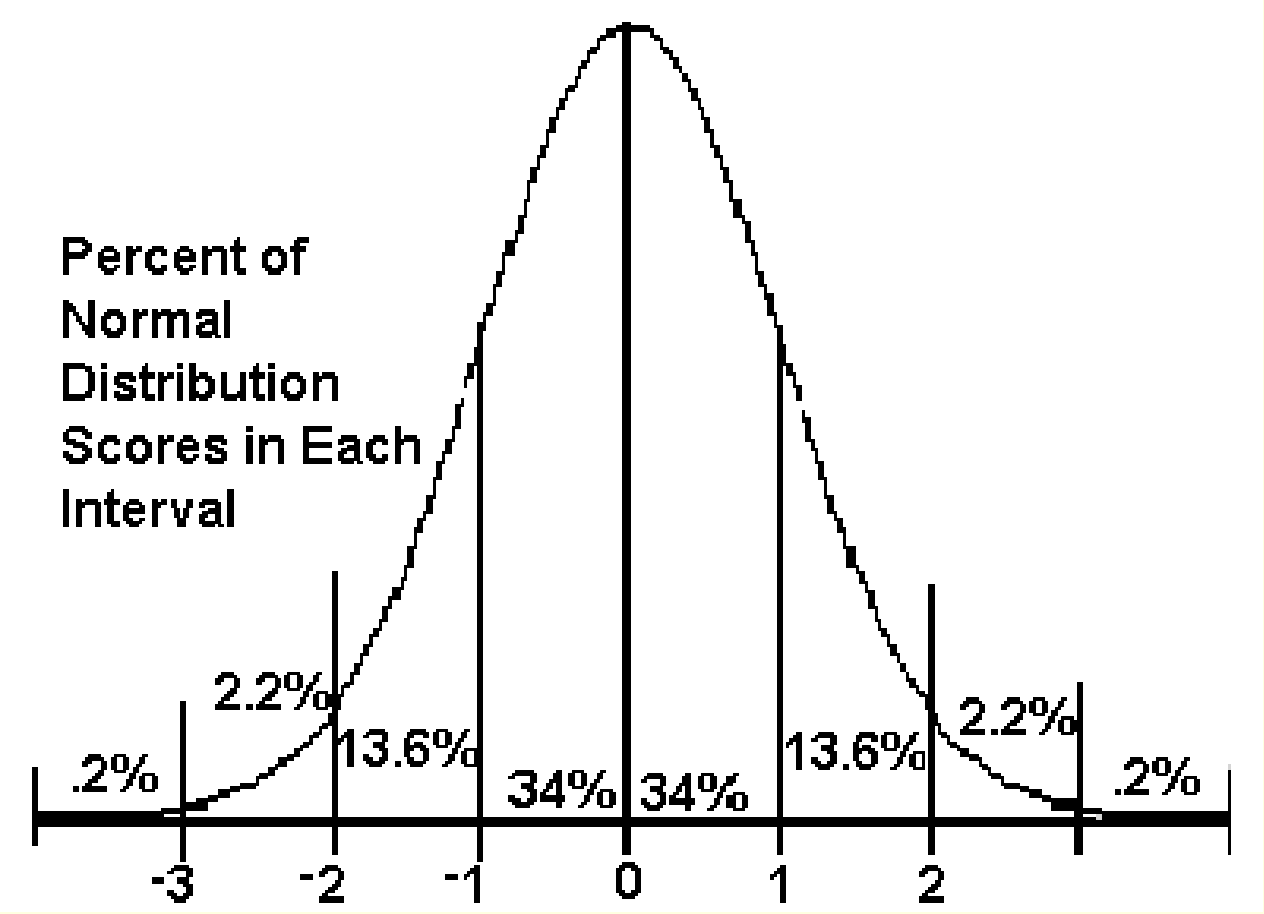


Data Aggregation: Horizontal

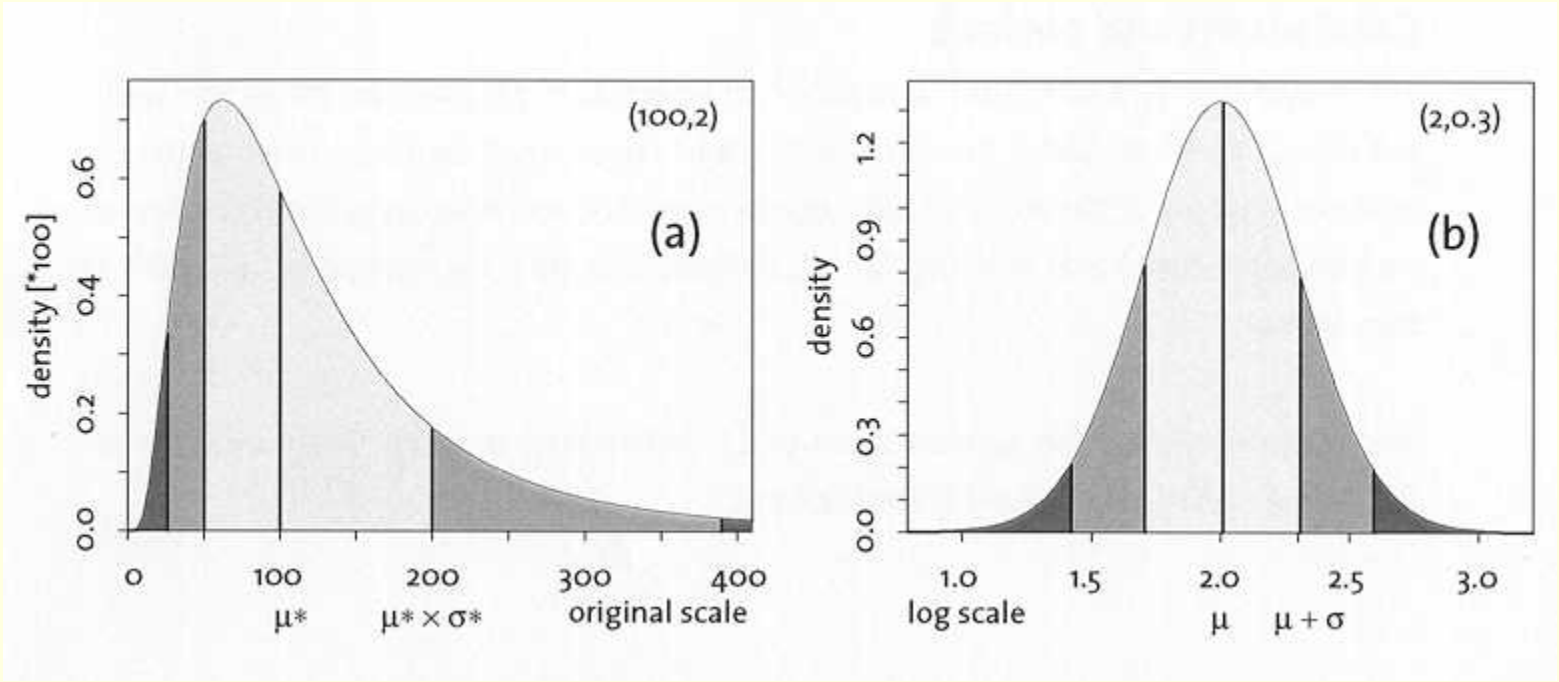
- US average electricity
- World average aluminum
- Washington wheat
- US corn-based ethanol
- Cradle to gate polyethylene

Any industry average is horizontally aggregated

Normal Distribution of Data

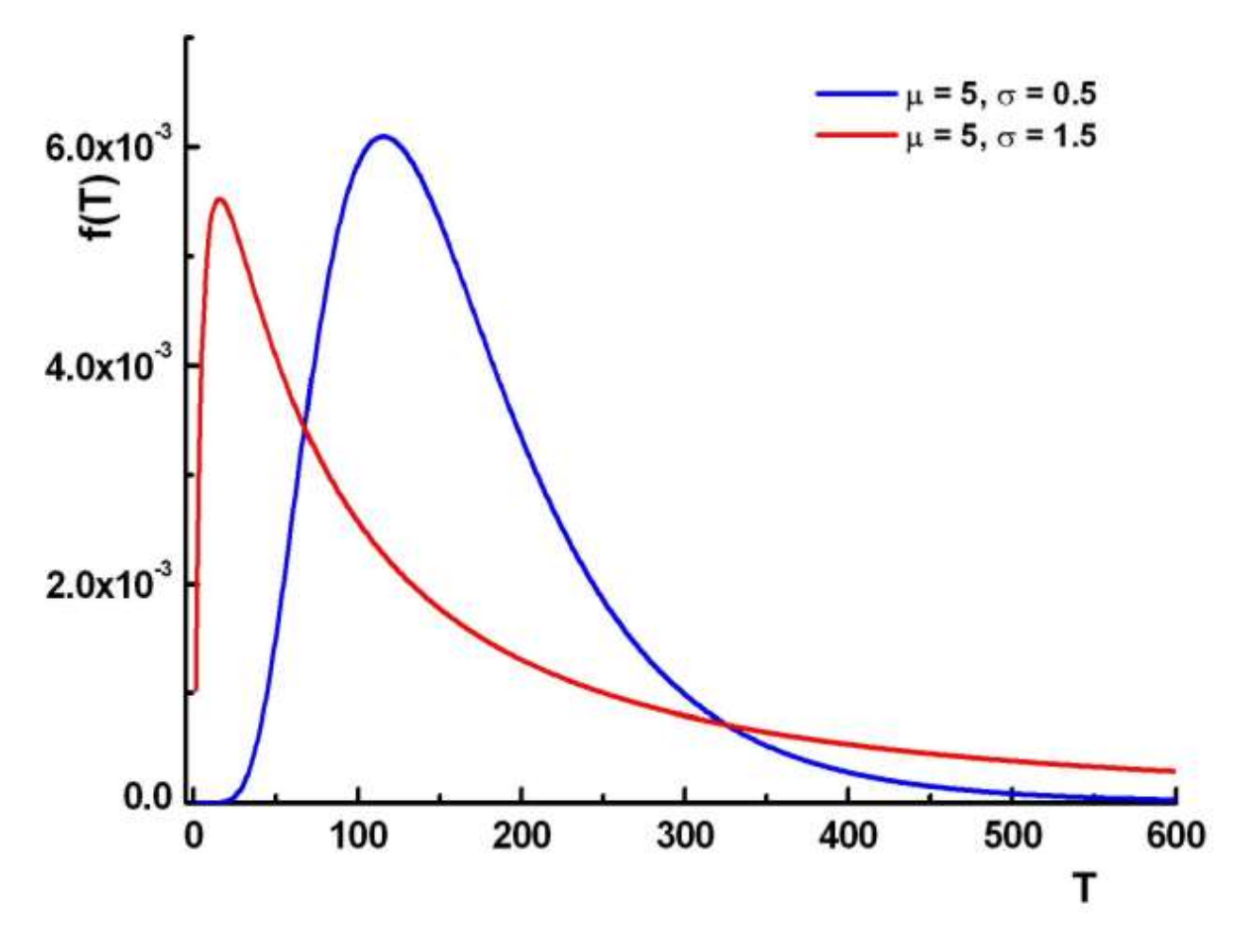


Lognormal Distribution of Data



The most common distribution of life cycle data

Why statistics matter



Free Governmental Databases

- US LCI Database
  - About 200 Unit Processes
  - North American Data
  - Operated by NREL: transparent data
  - New version expected soon

- European Reference Life Cycle Data System" (ELCD),
  - About 115 Unit Processes
  - EU data
  - Operated by the European Commission: transparent
  - New version expected soon

Commercial Databases

- Boustead Database
  - 13,000 unit processes
  - Commercial: About $30K initial: ongoing high annual fees
  - Owned by Boustead Consulting: non-transparent data
- Gabi Database
  - ~2500 Unit processes
  - Commercial: about $60K for full set with 15 add-ons
  - Owned by PE
- Ecoinvent Database
  - 4,000 unit processes
  - Non-for-profit: about $1500 initial; annual fees
  - Owned by Ecoinvent Center, a part of the Swiss Federal Institutes of Technology: Transparent data

Software Resources

- General purpose LCA software
  - GaBi PE Americas
    lwoods@pe-americas.com
  - SimaPro Pre Consultants
    Lise Laurin llaurin@earthshift.com
- Special-purpose lca software
  - The Environmental Impact Estimator, Athena, BEES, GREET, Umberto

Questions?

- Thank you for your attention!